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Development of Vibration Isolation Globes for High Workability

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Abstract. Anti-vibration gloves are used as protective equipment for vibration obstacles, but due to the thick anti-vibration materials of gloves, poor workability is pointed out by operators such as difficulty in manual work using fingertips. Therefore, in view of workability, we aimed to develop protective equipment that maintains vibration isolation performance even if the thickness of the vibration proof material is thin from the present.
Vibration measurement of ten kinds of materials with different materials and shapes was carried out, and vibration damping characteristics were analyzed and compared. With regard to the urethane-based material that was effective, we were able to develop a material with vibration damping performance (vibration transmission ratio less than 1) with a sheet thickness of 5 mm by examining the sheet shape, designing by simulation and vibration measurement / analysis.

1. Introduction

An operator using a portable tool such as a chain saw or a brush cutter or the like has a risk of developing a vibration disorder such as white wax disease or the like due to vibration exposure due to long-term work. Once the vibration disorder develops, it can not be expected to cure and there is no effective treatment other than trying to alleviate symptoms by symptomatic therapy treatment.

For work using tools such as chain saws and brush cutters that may cause localized vibration on the arm, it is recommended to use gloves with anti-vibration function as protection against vibration problems. However, commercially available vibration-proof gloves become thicker because the vibration-damping effect is given priority, and from workers, poor workability such as difficulty in manual work using the fingertips and difficulty in grip of tools such as tools has been pointed out. Therefore, in this research, in consideration of workability, the object is to develop a vibration proofing tool that maintains vibration damping performance even if the thickness of the vibration proof material is thin from the current situation. In this fiscal year, we aimed to develop anti-vibration material with thickness of less than 10 mm and vibration isolating performance.

2. Method of research

2.1 Examination of frequency to be vibration proofed

Frequency analysis of three types of chain saws was carried out in order to grasp the characteristic vibration components occurring from the chain saw. The model was carried out for G2551T (Komatsu

Zenoa), G3700EZ (Komatsu Zenoa) and MS 261 (STIHL) which are used for relatively forestry relations. The acceleration sensor was fixed to the handle grip of the chain saw, and the vibration when cutting the Japanese cedar and Japanese cypress material was measured. For vibration measurement and frequency analysis, a vibration analyzer (manufactured by MAL: Cut Pro) was used.

2.2 Comparison of anti-vibration materials

Vibration transmission rates of 10 types of materials with different materials and shapes (4 types of rubber system, 3 types of urethane system, 3 types of gel system) were compared.

The appearance of the rubber type material is shown in Fig. 1, the external appearance of the urethane type material is shown in Fig. 2, and the external appearance of the gel type material is shown in Fig. 3. The shape of the measurement material was a circle with a diameter of 45 mm, matching the diameter of the uppermost part of the vibration generator (manufactured by Emic: 514-A) used for vibration measurement. For natural rubber 1, natural rubber 2 and natural rubber 3, groove processing is performed on the surface of the material.

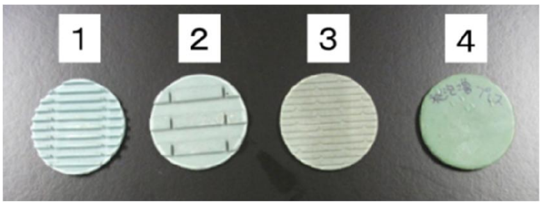

Fig. 1. 4 types of rubber

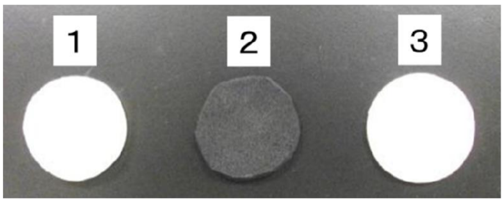

Fig. 2. 3 types of urethane

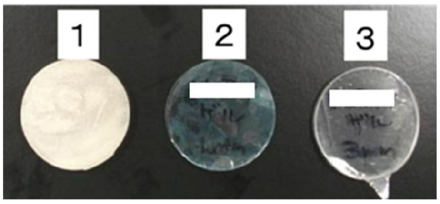

Fig. 3. 3 types of gel

The impedance method which is the performance measurement method of the vibration suppression material was used for comparison of materials. The measuring material was placed in the center of the vibration generator, and a weight was placed thereon. The weight of the weight was 3.3 kg. The vibration condition was set by a sinusoidal sweep test for grasping the natural frequency, and the frequency was 10 to 2,000 Hz and the acceleration was 9.8 m / s^2. Two acceleration sensors are used, which are control CH1 and measurement CH2. As shown in Fig. 4, CH 1 is installed inside the vibration generator. CH2 was fixed at the center of the upper part of the weight. The vibration transmission rate TR was obtained from the acceleration ratio of TR = CH 2 / CH 1. When the condition that the vibration transmission rate TR is less than 1 is satisfied, the material has vibration damping performance.

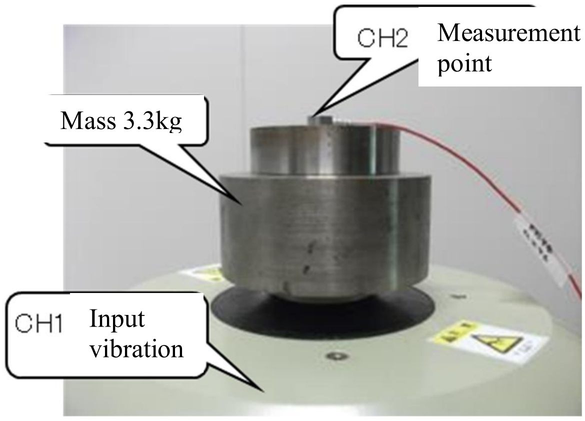

Fig. 4. Vibration measurement scenery of material

2.3 Design of shakeproof material shape by simulation

In order to improve the vibration damping effect of the material, it is common to shift the natural frequency of the material to a low vibration frequency and enlarge the vibration damping effect region. We focused on shape processing of material as a way to change natural frequency.

We changed the sheet shape of urethane based material and designed by simulation. For simulation software, Hyper Mesh made by Altair was used. A vibration isolating material is placed on the base on which vibration is generated, and a weight is placed on it. The size of the seat was set to 40 mm × 40 mm (1600 mm^2), which is equivalent to the vibration isolating material (circular area of 45 mm in diameter: 1590 mm^2) in the previous section. The thickness of the sheet was 3 mm. The urethane-based sheet was formed in a shape of punching a hole. Seven models were made by changing the size of punching and the number of punching. The model in which sixteen blanks (6 mm × 6 mm) are punched out, viewed from above in a state in which a weight is not placed. The mesh size was 0.5 mm.

Eigenvalues and vibration responses of each model were calculated, and shapes with vibration damping characteristics were searched.

2.4 Vibration characteristics of urethane sheet form prototype

The test and measurement method of the vibration isolation performance in the anti-vibration glove is specified in JIS T 8114. According to the standard, vibration is generated in the steering wheel, the vibration transmission rate from the steering wheel to the hand is obtained for wearing and non-wearing gloves, and the vibration damping performance is judged.

For the vibration isolating material to be embedded in anti-vibration gloves, measurements were carried out in an environment simulating the JIS standard in order to ascertain vibration isolation performance. Vibration measurement was performed on 15 different types of trial products (urethane 3: manufactured by C Company). The sheet shape prototype size was 105 mm × 95 mm, and the thickness was 5 mm.

In order to obtain the reference vibration transmission rate, measurements were made from a state without a sheet shape prototype. As shown in Fig. 5, the JIS standard was simulated and the steering wheel was fixed to a vibration generator (i250 / SA5M made by IMV). The acceleration sensor for control was installed on the upper left side of the steering wheel. In addition, the acceleration sensor for measurement was fixed with blue plastic, placed on top of the handle and held in the palm of the hand.

Vibration conditions were based on JIS standards, with random waves. For the two types of vibration signal M (frequency: 16 to 400 Hz, acceleration effective value 16.5 m / s^2 rms) and vibration signal H (frequency: 100 to 2,000 Hz, acceleration effective value 92.1 m / s^2 rms) , And vibration measurement was performed.

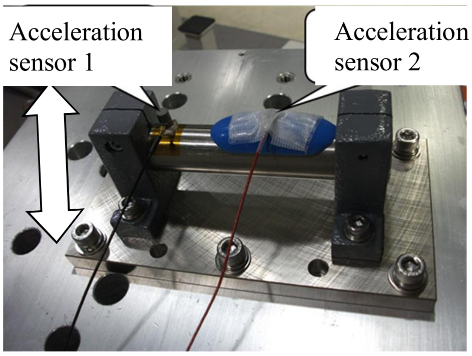

Fig. 5. Installation status of the steering wheel to the vibration generator

Next, the prototype of the sheet shape was wound around the handle, and the acceleration sensor for measurement was placed thereon and held with the palm of the hand. Vibration measurement was performed under the same conditions as above.

The modified vibration transmission rate TRs indicating the vibration damping performance is simulated JIS standard and is calculated by the following calculation. The measurement values of each acceleration sensor with no seat shape prototype and seat shape prototype are defined as follows.

・Acceleration sensor measurement value without control sheet：a1 m/s^2

・Measurement acceleration sensor measured value without sheet：a2 m/s^2

・Acceleration sensor measurement value with seat control：a3 m/s^2

・Measurement acceleration sensor measurement value with seat：a4 m/s^2

From the above, it is clear that the vibration transmission rateTRn＝a2/a1,　Vibration transmission rate with seat TRy＝a4/a3Was calculated. The corrected vibration transmission rate TRs is,　TRs = TRy / TRn.

3 Results and discussion

3.1 Examination of frequency for vibration isolation

The frequency at which the peak could be confirmed was set to be the frequency for vibration proofing. The vibration measurement result at the time of cutting of Japanese cypress material was also almost the same as that of Sugi material.

3.2 Comparison of anti-vibration materials

Fig. 6, Fig. 7, and Fig. 8 show the results of analysis of vibration damping characteristics by performing vibration measurement of four types of rubber system, three types of urethane system, and three types of gel system. The frequency in the figure represents the natural frequency of each material. In natural rubber 1 and natural rubber 2, natural vibration frequency was lowered by groove processing, and vibration damping effect area expanded. By comparing 10 types of materials, it was found that the material with the most vibration proof effect at vibration damping target frequency 500 Hz was urethane type. Three kinds of urethane series were expected to have equivalent vibration damping effect, but decided to proceed with material development with Urethane 3 (made by C company), which can keep the material cost low.

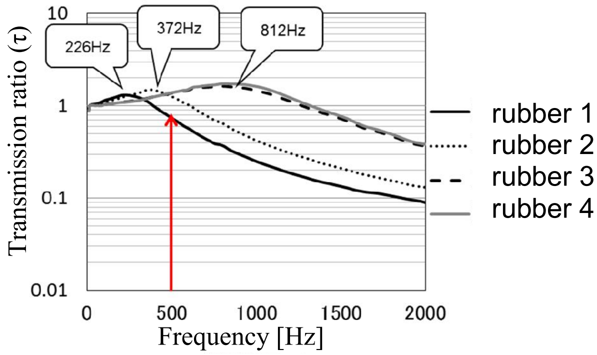

Fig. 6. Vibration measurement of rubber system

（The frequency in the figure is the natural frequency of each material.）

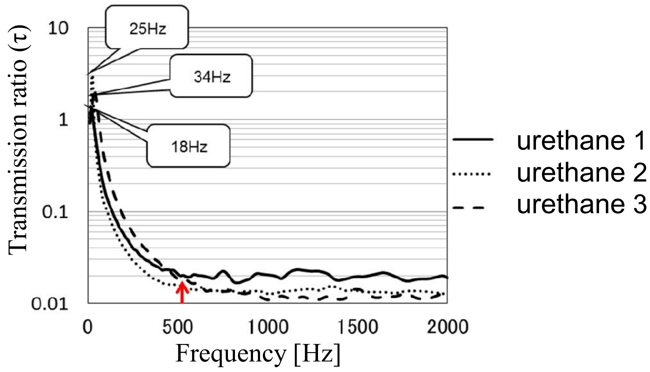

Fig. 7. Urethane type vibration measurement

（The frequency in the figure is the natural frequency of each material.）

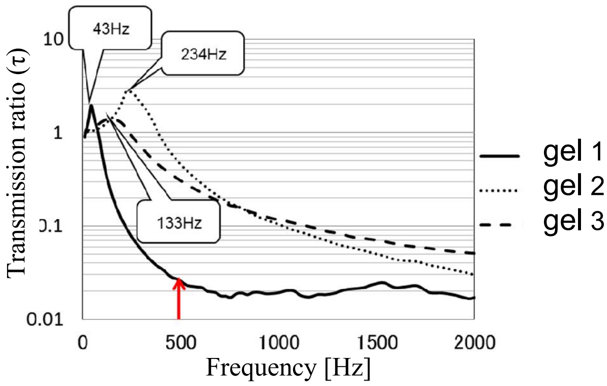

Fig. 8. Vibration measurement of gel system

（The frequency in the figure is the natural frequency of each material.）

3.3 Design of anti-vibration material by simulation

Seven models were made by changing the sheet shape of urethane 3 (made by C company). The area ratio is the ratio of the total punched area to the area of the entire sheet (40mm×40mm =1600mm^2). As the area ratio increased, there was a tendency for the vibration transmission rate to decrease. That is, it was expected that the vibration damping effect could be improved by punching the sheet.

3.4 Vibration Characteristics of Urethane Sheet Shaped Prototype

Adding random waves to the prototype, vibration measurement and analysis of vibration damping characteristics. The area ratio was the ratio of the total punched area to the area of the entire sheet (105mm×95mm =9975mm^2)

Compared with a sheet without processing, it is understood that the punched sheet has a tendency to lower the corrected vibration transmission rate and to improve the vibration damping performance. In the vibration analysis of the vibration signal M, the condition of the corrected vibration transmission rate TRs <1 was not satisfied in the sheet without processing, but by performing punching processing, the condition of TRs <1 can be satisfied.

The results of plotting the relationship between the sheet area ratio and the corrected vibration transmission rate for each punching diameter. According to Fig. 9, since the corrected vibration transmission rate decreases when the area ratio is around 30 to 40%, it can be inferred that when the material is manufactured with the area ratio in this range, it becomes a particularly effective anti-vibration material.

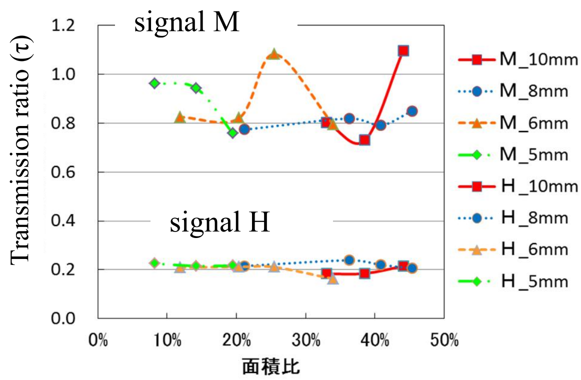

Fig. 9 Relationship between area ratio per punching aperture and corrected vibration transmission rate
(M and H are vibration signals, and numbers after that are punching diameters.)

3. Conclusion

(1) Among the 10 kinds of materials with different materials and shapes, it was found that the urethane material has the most vibration damping effect.

(2) It was possible to obtain a material having a thickness of 5 mm of a urethane-based sheet and having anti-vibration performance (vibration transmission ratio of less than 1).

(3) It was found that in the vibration analysis of the vibration signal M, it is possible to satisfy the condition of corrected vibration transmission rate TRs <1 by punching processing.

References

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